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mented, although the difference in this respect between "fault-bars" and "fundamental bars" is not marked, but results in the melanin pigment being "laid down in alternating light and dark transverse bars."

Among the results summarized by the author as confirmed by or resting upon these investigations may be mentioned: The occurrence of fault-bars normally in all birds and in all feathers; they can also be produced experimentally. A daily blood-pressure rhythm with a minimum pressure between 1 and 5 A.M. "The reduced nutrition brought about daily by this minimum blood-pressure; the disadvantageous position, in relation to the blood, of the pigment and barbule elements of the feather; together with the very rapid rate at which feathers grow, furnish the complex of conditions which bring unfailingly into existence a fault-bar, and to a more or less appreciable extent a light fundamental bar, at perfectly regular intervals in the entire length of every feather formation." "The melanin pigment of the feathers of birds shows, under favorable conditions, quantitative variations of the pigment produced in response to changes in the available food supply. This is an additional evidence that this pigment is not a derivative of hæmoglobin, but of the serum or cell proteids." "These results furnish a description, in the terms of physiology, of the mechanism of the 'inheritance' of certain fundamental color-characters of all birds." "The fundamental bars furnish the starting point for all evolutionary studies on the color-characters of birds."

These investigations may well serve as the foundation for researches upon the color-characters of birds, but whether they are to throw much light upon the genesis of color patterns in plumage remains for the future to disclose. It may be noted that no reference is made in this connection to the cause of differentiation of feather structure, treated by the author in a former paper.

J. A. A.

HERPETOLOGY

Ruthven's Variations and Genetic Relationships of the Garter-snakes.[1]—This paper of over two hundred pages, devoted to a single genus of snakes, marks a new departure in North American herpetology in respect to methods of procedure. An attempt is made first to determine the value of the characters commonly employed in distinguishing the different forms of the group, as scutellation and color, through study of the normal range of variation in the number of dorsal rows of scales, number and arrangement of the labial and preocular plates, the number of the ventral and subcaudal plates, and the position and color of the stripes. All this is worked out with great care and detail for each form, so far as material is available, which includes about 3,000 specimens, gathered from throughout the known range of the genus. Distinction is made between individual, sexual and geographic variation.

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[1] Ruthven, Alexander G. Variations and Genetic Relationships of the Garter-snakes. *U. S. National Museum Bulletin* 61, 8vo, pp. xii + 301, with 82 text figures and 1 half-tone plate. Washington, Government Printing Office, 1908.

The individual variation in the number of rows of dorsal scales, and the variation in the different forms of the group, is found to be due to the dropping out of certain rows. The law is thus stated: "The individual, geographic and racial variations in the number of dorsal scale rows in the garter-snakes is brought about by the shortening and loss of the same scale rows as are ordinarily dropped posteriorly in conformity with the taper of the body, and there is evidence that this decrease is due to a dwarfing of the body."

The cause of variation in the number of labial plates is not easily explained, but it is believed that there is good reason "for concluding that whatever the factors may be that influence the number of labial plates, the variations are geographic and have been the basis for the racial differences that now exist."

The color pattern in Thamnophis consists of three light longitudinal stripes—a median, and a lateral stripe on each side of the body—on a dark ground. They vary in width in different individuals of the same form, and also more or less in color. The median stripe is the most variable, and in some of the forms it is more or less obsolete. The lateral stripes are constant in position (in reference to the rows of scales involved), and as the position varies in different groups of forms it is available in diagnosis. Simple variation in color, however, has little diagnostic significance, owing to the wide range of individual variation within each form; "and, even when there are well marked geographic differences among forms, those in the same region tend to be similarly colored, as Allen has pointed out a number of times in mammals and birds, so that it is impossible to distinguish them sharply on this basis.'' Thus there is ''a marked increase in bright colors in the Pacific coast region in Washington, Oregon and British Columbia,'' and an increase in this same region ''in the amount of black pigment at the expense of the paler colors.'' ''A tendency toward a paler ground color and lighter stripes'' is noted in western Texas, southern New Mexico, southern Arizona and northern Mexico, and ''a tendency toward the production of red pigment on the Great Plains,'' and ''toward dark colors in the forest region of eastern United States.''

As a result of these detailed studies of variation and their probable causes and significance, the taxonomy of the group here presented is quite different from that of preceding authors. Only 19 ''forms'' are here recognized, in place of the 30 currently admitted by herpetologists. The author says:

> "It may seem the extreme of 'lumping,' to assert that there are but four great groups or lines of descent in the garter-snakes, but I believe the evidence is sufficient to warrant the assertion."

These four groups are the *radix, sauritus, elegans* and *sirtalis* groups. He explains in a footnote (p. 39):

> "It is best at the outset to ignore all questions of species and subspecies until their status is established, and to speak of these as forms. Forms, therefore, in the sense employed in this paper, are actual combinations of traits, having geographic extent, irrespective of whether they are isolated (species) or intergrade with their neighbors (subspecies). Detailed discussions of questions of nomenclature are also omitted, although the names are in every case the ones that, in the light of these investigations, we judge to be the right ones, following the International Code of Zoological Nomenclature. The proper name of each form will be found in the footnotes, together with the synonomy."

In the ''Table to illustrate the combinations of traits into forms, groups and divisions in the garter-snakes'' (pp. 40, 41), the ''forms'' and ''groups,'' and ''primary divisions'' (the latter simply numbered I and II) are listed, but it would have been a great convenience if he had given somewhere in his monograph a list of the ''forms'' with their full names as here employed. The form of nomenclature given in footnotes implies the provisional recognition of 12 species (binomials) and seven additional subspecies (trinomials), as follows:

1. *Thamnophis megalops* (Kennicott).
2. *Thamnophis marcianus* (Baird and Girard).
3. *Thamnophis radix* (Baird and Girard).
4. *Thamnophis butleri* (Cope).

Radix group.

5. *Thamnophis sauritus* (Linné).
5*a*. *Thamnophis sauritus proximus* (Say).
5*b*. *Thamnophis sauritus sackeni* (Kennicott).

Sauritus group.

6. *Thamnophis angustirostris* (Kennicott).
6*a*. *Thamnophis angustirostris melanogaster* (Peters).
7. *Thamnophis scalaris* (Cope).
8. *Thamnophis phenax* (Cope).
9. *Thamnophis hammondi* (Kennicott).
10. *Thamnophis ordinoides* (Baird and Girard).
10*a*. *Thamnophis ordinoides elegans* (Baird and Girard).

Elegans group.

11. *Thamnophis eques* (Reuss).
11*a*. *Thamnophis eques sumichrasti* (Cope).
12. *Thamnophis sirtalis* (Linné).
12*a*. *Thamnophis sirtalis parietalis* (Say).
12*b*. *Thamnophis sirtalis concinnus* (Hallowell).

Sirtalis group.

Of these groups he states (p. 186) that the *sirtalis* group "is without doubt the least diversified," since its members are given by most herpetologists only subspecific rank, owing to their evident intergrading.

Later on in the paper, in his "Discussion of Origins," he gives his reasons for believing that the genus Thamnophis had its origin in northern Mexico, and not in southeastern United States, as held by Cope and Brown. The four "groups" are each represented in northern Mexico and southwestern United States, and "each group is formed of a line of directly related forms, the extremes of which are very distinct," and these lines converge toward northern Mexico. He further states, under "Method of Evolution of the Forms" (p. 192): "If the range of the forms in the different groups of garter-snakes be carefully examined it will be found (1) that the different forms of the same group are found in different geographical regions, characterized by different environmental conditions; (2) that the area along the common boundary of two forms of the same group, where transition in characters takes place, is relatively narrow''; just as has long been known to be the case in mammals and birds, and as Ortmann has recently affirmed to be the rule in crawfishes.

He considers that

> "Experimental work alone can sufficiently reveal the influence of the environment upon the dwarfing and scutellation of these snakes. In the case of the garter-snakes, however, it should be noted: (1) That most of the forms are the result of dwarfing. (2) That the amount of dwarfing does not seem to be directly associated with the nature of the environment, for the form inhabiting a particular region is only slightly different from its nearest neighbor in the same group, while forms of widely different scutellation may inhabit the same region. Thus the conditions which apparently determine the scutellation of any form is the scutellation of its immediate progenitor, and the dwarfing it has itself undergone."

He believes that he is ''justified in concluding that the dwarfing is associated in some way with the environment.'' He then cites Allen's law (1876)[2] that the environmental conditions at the center of origin are most favorable for the existence of any group, and says:

> "However this may be, the following facts will stand: (1) That the maximum scutellation and size in the genus Thamnophis occurs at the center of dispersal, and the forms that have been produced in the history of its migration have been formed principally by dwarfing and reduction in scutellation; (2) that the variation in the number of scales in the different series is definite and not promiscuous, and is correlated in a remarkable degree with changes in the environment. The development of the different groups has thus been orthogenetic."

He continues:

> "From these facts it seems to me that the most tenable hypothesis of the evolution of the genus Thamnophis is that it originated and became differentiated into four main groups in northern Mexico. From

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[2] ''In a general way, the correlation of size with geographical distribution may be formulated in the following propositions:

''1. The maximum physical development of the individual is attained where the conditions of environment are most favorable to the life of the species. . . .

''2. The largest species of a group (genus, subfamily, or family, as the case may be) are found where the group to which they severally belong reaches its highest development, or where it has what may be termed its center of distribution. . . .''—*Bull. Geol. and Geograph. Surv. Terr.*, Vol. II, No. 4, p. 310, July 1, 1876.

this region the groups radiated in all directions, but principally to the northward, and wherever they entered dfferent regions the changed environmental conditions acted as an unfavorable stimulus, which retarded growth, and differentiated the groups into dwarfed forms."

The first forty pages of this notable monograph are devoted to the taxonomy, distinctive features, and "variations" of the garter-snakes; the next one hundred and forty to a detailed account of the various "forms," including description, habits and habitat relations, range, variation and affinities; then follow about twenty pages of conclusions and general discussion, a bibliography of about 85 titles, and the index. The eighty-two text illustrations consist of diagrams showing the arrangement of the dorsal scale rows, the head plates, and the arrangement and numerical variation in the labial plates; diagrams illustrating the scale formula and its variations in the different forms; distribution as indicated by locality records (plotted on maps); and habitat views (half tones). It is altogether an excellent piece of work, which we hope to see emulated in other fields of taxonomic research, for which there is ample opportunity in the higher classes of vertebrates.

In his introduction Dr. Ruthven alludes to the "barrenness of general results" that has marked the systematic work in herpetology, due in part to the method employed, which has been "largely analytical in its nature, being for the most part descriptive of the existing diversities." While such work is important, it only makes known present conditions; as the author forcibly says, a knowledge of the processes that have brought them about is of the greater interest, since "systematic work can only become a true science when it seeks to formulate the laws involved in the history of the present forms. After analysis, therefore, as has been said, comes the need of a larger synthesis."

Dr. Ruthven's monograph strongly appeals to the present reviewer for two reasons: First, when curator of reptiles at the Museum of the Boston Society of Natural History some thirty years ago, he spent much time in trying to unravel the intricacies of variation in the garter-snakes, with a view to publication of the results, but other and more pressing interests intercepted the work; secondly, he repeatedly in the early seventies made strong appeals for the synthetic method in systematic work, and has published a large amount of data on individual, sexual and geographic variation. Forty years ago systematic work was almost wholly analytic, and especially so in respect to the mammals, birds and reptiles of this continent. In my paper "On the Mammals and Winter Birds of East Florida, with an examination of certain assumed specific characters in Birds," etc., published in April, 1871,[3] the conclusions arrived at respecting "species" and specific characters are thus summarized:[4]

"(1) That the majority of nominal species originate in two principal sources of error, namely, (*a*) an imperfect knowledge of the extent and character of individual variation, and (*b*) of geographical variation. (2) That this imperfect knowledge is mainly due to the neglect of zoologists to study with sufficient care the common species of their respective countries, whence has arisen a faulty method of investigation and erroneous ideas respecting species and specific characters. (3) *Instead of the method at present pursued by a large school of descriptive naturalists—the analytic, or the search for differences—being the proper one, that synthesis should be duly combined with analysis, and that general principles should be sought as well as new forms, or so-called 'new species' and 'new genera.'* (4) It is claimed that nothing is to be gained by giving binomial names to climatic or other forms, in cases where, however considerable the differences between them may be, a complete transition from the one to the other can be traced in specimens from intermediate localities, notwithstanding the plea sometimes urged that their use affords 'convenient handles to facts.'"

No 3 of these conclusions,[5] here italicised, denotes the class of research exemplified by Dr. Ruthven's monograph. His method of approach to the problem before him is thus stated:

"Three steps are necessary to determine the genetic relationships and simplify Cope's elaborate arrangement of the group: (1) The value of the characters must be determined; (2) geographic probabilities must be utilized; (3) similarities and intergradations must be sought."

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[3] *Bull. Mus. Comp. Zool.*, Vol. II, No. 3, pp. 161–450.

[4] *L. c.*, p. 163.

[5] No. 4 may be considered as an entering wedge which led up to the later adoption of trinomials. In 1872 (*Bull. Mus. Comp. Zool.*, Vol. III, No. 6, pp. 119 *et seq.*, July, 1872) varietal names were advocated and systematically adopted for intergrading forms, which were referred to as subspecies or races, the same method of designation being almost simultaneously employed by other American ornithologists and mammalogists. For several years the third term of the name was separated from the second by the interposition of the abbreviation "var.," or by a letter (Roman or Greek, according to the preference of the author); in 1877 and 1878 trinomials, pure and simple, came generally into use in this country for birds and mammals, and soon after for reptiles.

As a result the 43 forms (20 species and 23 subspecies) recognized by Cope in his posthumous work "The Crocodilians, Lizards, and Snakes of North America" (Rep. Smiths. Inst., 1898), are reduced to nineteen; and of the twenty-two names given by Cope eighteen appear only as synonyms. Nearly seventy names have been conferred on these nineteen forms, or an average of three and a half for each.

Dr. A. E. Brown, the last preceding reviser of the group, in his "Review of the Genera and Species of American Snakes, north of Mexico," published in 1901,[6] reduced the number of forms to eighteen—ten species and eight subspecies; he proceeding on somewhat the same lines as Ruthven, namely, "that a knowledge of the laws under which forms are developed is to be best gained by a study of variations." While the number of forms admitted by the two authors is practically the same, the taxonomic results are widely diverse.

Dr. Ruthven believes that the garter-snakes will be found to furnish excellent material for experimental research, as they are hardly in captivity, and prolific; and that the first problems to be attacked are the inheritability of scale characters and the influence of inbreeding and unfavorable conditions of food and temperature. But it is to be remembered that experimental research must necessarily be conducted under unnatural conditions, and that the results do not necessarily show what has taken place under natural environments. While the results thus obtained are always interesting and suggestive, they can not be looked upon as conclusive respecting what has actually occurred under natural conditions.

J. A. A.

LEPIDOPTERA

Hybrid Lepidoptera.—Although published more than a year ago, Mr. J. W. Tutt's account of hybridization and mongrelization in Lepidoptera is probably scarcely known to evolutionists in this country. The two chapters in which he sums up and discusses all that is known on these subjects are prefaced to a much larger work, the first volume of the "Natural History of the British

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[6] *Proc. Acad. Nat. Sci. Phila.*, 1901, pp. 10–110.